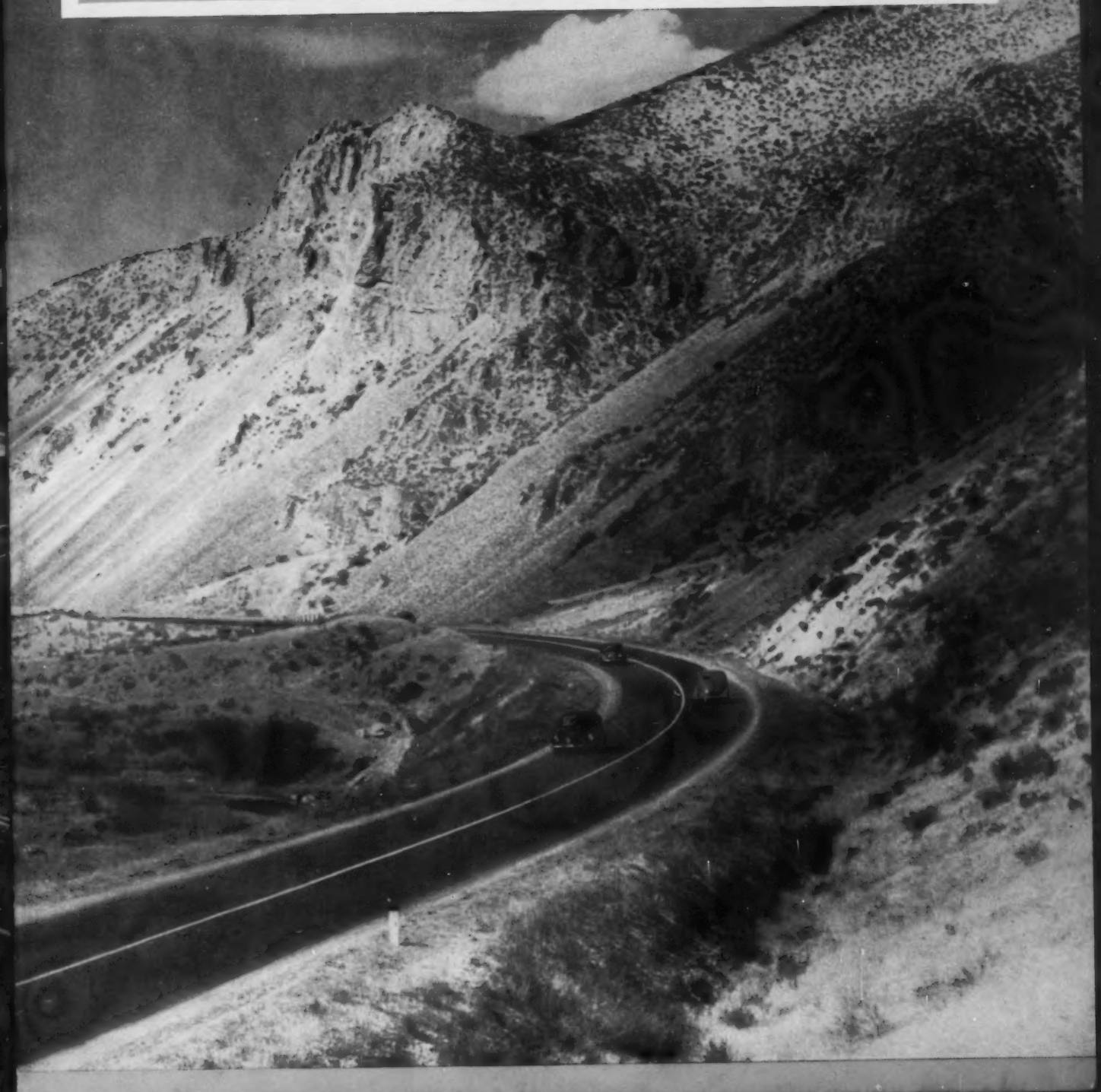
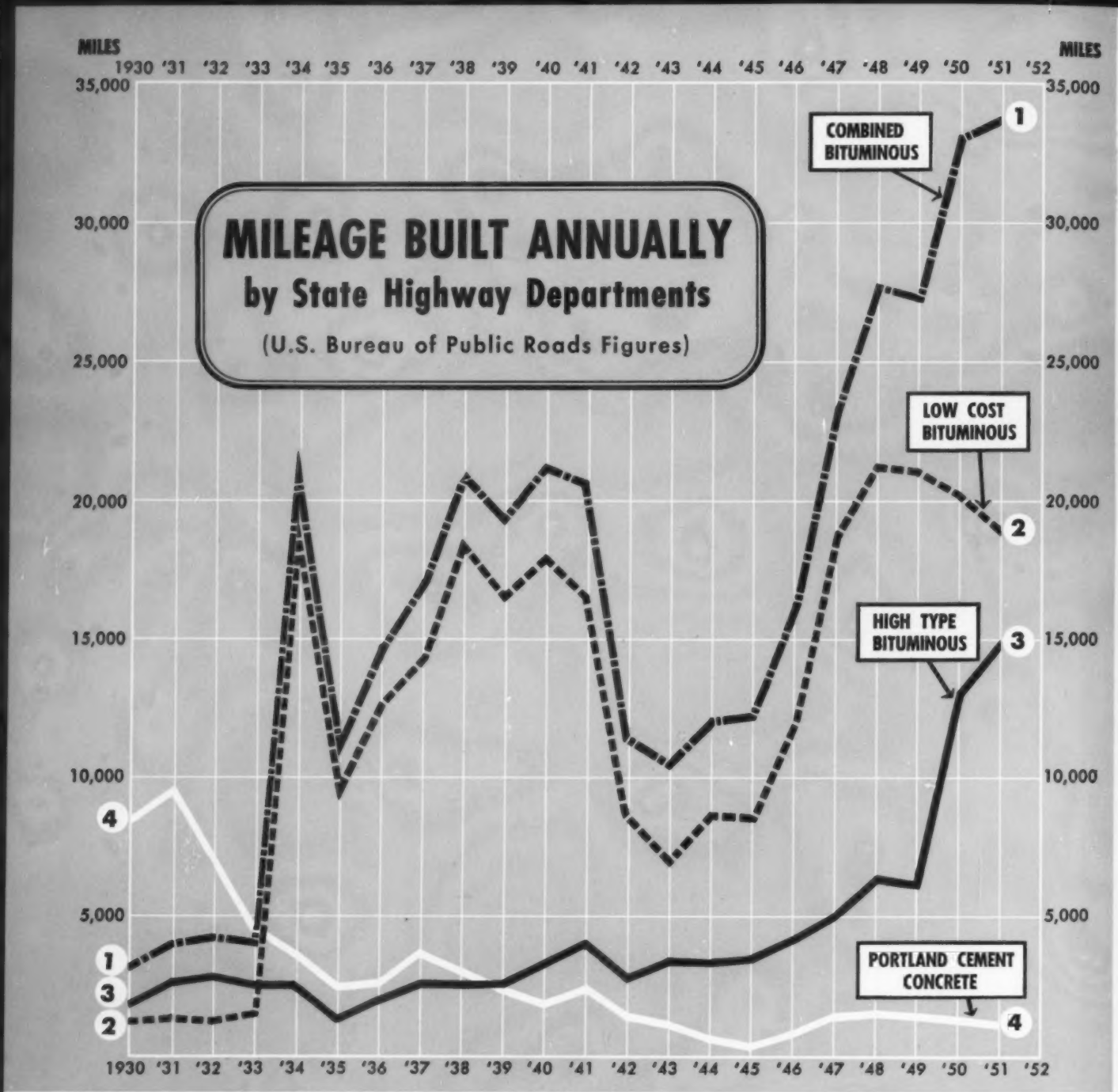
ASPHALT INSTITUTE *Quarterly*

OCTOBER 1953





In the above Chart the white line, descending practically without interruption for the past twenty years, records the steadily decreasing mileage of Portland Cement Concrete roads built each year by the forty-eight State Highway Departments. It does not include Town and County rural roads.

The black solid and dash lines on the Chart record the increasing annual mileage construction of Bituminous roads by these Departments, particularly rapid since 1945.

As shown, the above are not cumulative figures, but year by year they have, of course, radically changed the "existing roads" totals. In 1940 the then-existing Portland Cement Concrete total was 95,000 miles; the High Type Bituminous 40,000 miles. Now the Portland Cement total is down to 73,000 miles; the competitive High-Type Bituminous up to 113,000 miles. The State Highway Departments have been wisely governed by their basic requirements of quality consistent with cost.

CHARTED BY THE ASPHALT INSTITUTE, OCTOBER 1953

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The names of the Member Companies of the Institute, who have made possible the publication of this magazine, are listed herein on page 15.

EDITORS

Bernard E. Gray, *President of The Asphalt Institute*
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COVERS

The double covers picture, presented through the courtesy of the Nevada Department of Highways, shows U. S. 40, its pavement an asphalt plant-mix over a flexible type base, on its coast-to-coast, 3000-mile route between Atlantic City and San Francisco. Here it winds through Nevada's rugged Carlin Canyon in the valley of the Humboldt River along the California Trail.

The Chart on page 2 shows a "Combined Bituminous" total of over 35,000 miles built by State Highway Departments in the latest year reported. This increased to over 700,000 miles the total surfaced Bituminous network of roads and streets on all rural and urban systems throughout the United States.

EDITORIAL

For some time there has been much talk and writing about the need for new and better roads. Many say that unless something is done shortly, our road system will fall into complete disrepair. But the facts do not bear this out, and it is time that a careful appraisal were made of the actual conditions and the real requirements for providing orderly improvement.

True, there have been large increases in automotive traffic since 1946. It is also true that facilities to take care of this traffic have not increased at a rate fully commensurate with need. However, post-war annual *construction and maintenance* expenditures for roads and streets have increased from $1,934,000,000 in 1946 to $5,014,000,000 in 1952. In reviewing these figures, the prophets of doom imply that only construction items improve the situation. This is erroneous, for, while maintenance in some instances does merely maintain a static condition, the greater portion of such work leads to improved highways, not only in respect to surfaces, but also drainage and shoulders. Through both new construction and maintenance improvements, highways are, in 1953, decidedly superior to what they were before the war; and, although there is much to be done before a complete balance between traffic and highway is secured, a common-sense attitude toward the matter is recommended.

A truly vast improvement in the highway situation has taken place in recent years. In 1930, on state highway systems, the *net* result from construction activity for all preceding years was reported as 263,274 existing improved miles. Between 1930 and 1950, as reported by the U. S. Bureau of Public Roads, State Highway Department construction activity resulted in a total of 588,992 miles of roads actually built or further improved in these twenty years. How much of this was *pavement* of bituminous and portland cement types is shown in graphic form in annual figures on opposite page.

One reason that highways appear so congested is that, coincident with the great increase in motor vehicles, there has been such a large movement of the population from rural areas to the cities. It is around the cities that congestion is most noticeable, and it is here that concentrated effort will be required to relieve the situation. Probably one-half of all traffic movement takes place in and around these urban areas, where further provision must be made for the rapid movement of large numbers of people traveling to and from homes, factories and offices. In addition, possibly half of the Interstate System, or some twenty thousand miles, may need partial relocation. On most of the remaining mileage, which constitutes over 90% of the total, the existing roads can be improved largely on their present location.

This improvement should take the form of widening and resurfacing and thus permit freer movement of the modern large vehicle. Many roads are inadequate because the pavement, often only 20 feet or less in width, is just too narrow. A road 24 feet wide, however, with adequate shoulders, will easily carry upwards of 4,000 vehicles per day. Relatively few roads have this much traffic, while the great majority have far less. From a cost standpoint it is much more feasible to rehabilitate three to five miles of road on the existing right-of-way than to build one mile on a new location.

It is apparent, then, that (1) useful highway expenditures are much larger than generally supposed; (2) most highways are being steadily improved, although a faster rate is desirable; and (3) direction of expenditures in accordance with need is the real requisite today.

A MAJOR STREET IMPROVEMENT IN DENVER

By John R. Banning
District Engineer, the Asphalt Institute

East Colfax Avenue — where an old 30-foot concrete pavement has become a small part of the foundation for an improved, high-type asphalt boulevard 80 foot wide.

Photo: Colorado State Highway Department

Good judgment comes from experience and experienced engineers always plan carefully. No type of municipal engineering requires more good judgment, wise planning, and experience than that involved in rehabilitating,widening and resurfacing city streets. Many ramifications are encountered in this type of construction, such as meeting established property line grades, reconstructing storm sewers, providing surface drainage, facilitating street openings for telephone, telegraph, light and power conduits, and laying street car tracks. When such projects are undertaken on heavily-traveled arterial streets merchants are always upset, due to the fear that their establishments will be closed off to their regular customers, with a loss of business, which of course means an economic loss to them. Hence, it requires a great deal of finesse and experience to outline the construction sequences so that no loss to the merchants is involved.

In the Denver area, widening and resurfacing projects have been undertaken since the early '30s, including the widening and resurfacing of old portland cement concrete, brick, stone blocks, wood blocks, and old bituminous pavements. Therefore, engineers in Denver have developed a wide range of knowledge of this type of construction.

EAST COLFAX AVENUE IMPROVEMENT

The most recent project, finished in 1952, presented an interesting problem which required the most modern type of design in order to handle the ever-increasing traffic on East Colfax Avenue, which carries the traffic of U. S. Highways 36, 40, and 287 leading into Denver from the East, in addition to a heavy volume of local traffic. Mixed, light, and heavy vehicular traffic on this route has increased during the last fifteen years from 8,000 to 30,000 vehicles per day.

The original pavement consisted of a portland cement concrete pavement 30 feet in width. This pavement had become so broken up and distorted that it was no longer serviceable for present traffic movement. The street was first improved by widening to 80 feet, the design calling for a 12 foot median strip, two 32 foot roadways and a 2 foot integral curb and gutter on each side. For the median strip, a curb was installed which had to be dowelled into the old pavement. The construction of this median curb presented a problem finally overcome by constructing angle forms which were installed by drilling holes in the old concrete, and driving pins at regular intervals to hold them in place.

1. Excavating for East Colfax Avenue Improvement, using front-end loader

The area between the median curbs was constructed by placing variable thicknesses of granular compacted base, prime coating, and then adding 1" of asphalt pavement.

ASPHALT REPLACES OLD CONCRETE

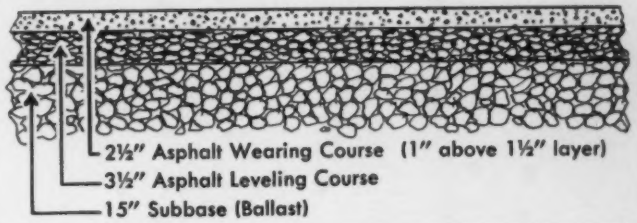
The old pavement was broken up with heavy rollers, as it was not economical to under slab seal the old pavement to restore its contour or bearing strength. Where the finished grade was from 2½" to 6" above the old concrete pavement, the fill over the pavement was made entirely of an asphalt leveling course, blade-laid to correct irregularities and to bring the grade up to within 2½" of finished grade. A 2½" wearing course was then placed in two layers, the first course being 1½" thick and the top course 1", both courses being laid with a paver. Where the finished grade was more than 6" above the old concrete pavement the old surface was broken up and covered with a variable thickness of compacted granular base course, and a 2½" wearing course then constructed, placed in two layers.

BALLAST MATERIAL FOR SUBBASE COURSE

Excavation was accomplished by conventional type of dirt-moving equipment and front-end loaders. Upon the compacted subgrade a 15" subbase course was laid, compacted and rolled. The ballast material was dumped on the subbase in layers, in such a manner that non-uniformity in the grading from load to load in the trucks could be adjusted or eliminated as far as practicable. This was accomplished by spreading the first series of loads at such intervals as to provide an amount equal to one-third of the ballast required for the total layer being placed. The material was then bladed into a small windrow. The second and third series of loads were spread in the same manner, each spread being bladed adjacent to or over the preceding windrow in such a manner as to form a composite windrow of the three spreads. The distance of spreading was held to approximately three thousand feet before the next spread was placed. Blading of the material into the windrow followed within a reasonable time after dumping the loads so as to cause as little inconvenience to traffic as possible.

The completed windrow was moved by heavy blade graders into a windrow on one side of the street; then processed with a revolving motion until uniformity of the mass was secured and then laid to proper width and thickness. Material that did not contain sufficient moisture to avoid segregation of the particle sizes was wetted prior to and during the processing operation. After the material had been processed and spread, it was rolled a minimum of four complete coverages with suitable rollers to assist in compaction. The use of water in an amount which resulted in the accumulation of a mulch of fines at the surface under the action of the rollers was avoided.

TYPICAL NEW PAVEMENT CROSS-SECTION OF EAST COLFAX AVENUE IMPROVEMENT



Over this sub-base course a 3½" crushed gravel base was placed wet, rolled and compacted to optimum density. Upon this a 2½" asphalt wearing surface, machine-laid pavement was applied.

The gradation of the subbase and base courses were as follows:

Subbase:	Passing 3" Sieve	100%
	" #10 "	not more than 80%
	" #200 "	3-12%
Base Course:	Passing 1" Sieve	100%
	" ¾" "	95-100%
	" #4 "	40-70%
	" #10 "	25-55%
	" #200 "	5-12%

This base course material it was specified must have a resistance of 77, as measured by the Hveem stabilometer.

ASPHALT PAVING MIX

All the asphalt paving mix met the following specifications:

Passing the	¾" sieve	100%
" "	½" "	95-100%
" "	#4 "	50-60%
" "	#8 "	40-50%
" "	#30 "	25-38%
" "	#100 "	12-20%
" "	#200 "	6-10%
Asphalt cement		5-7%

85-100 penetration asphalt was used in the mix.

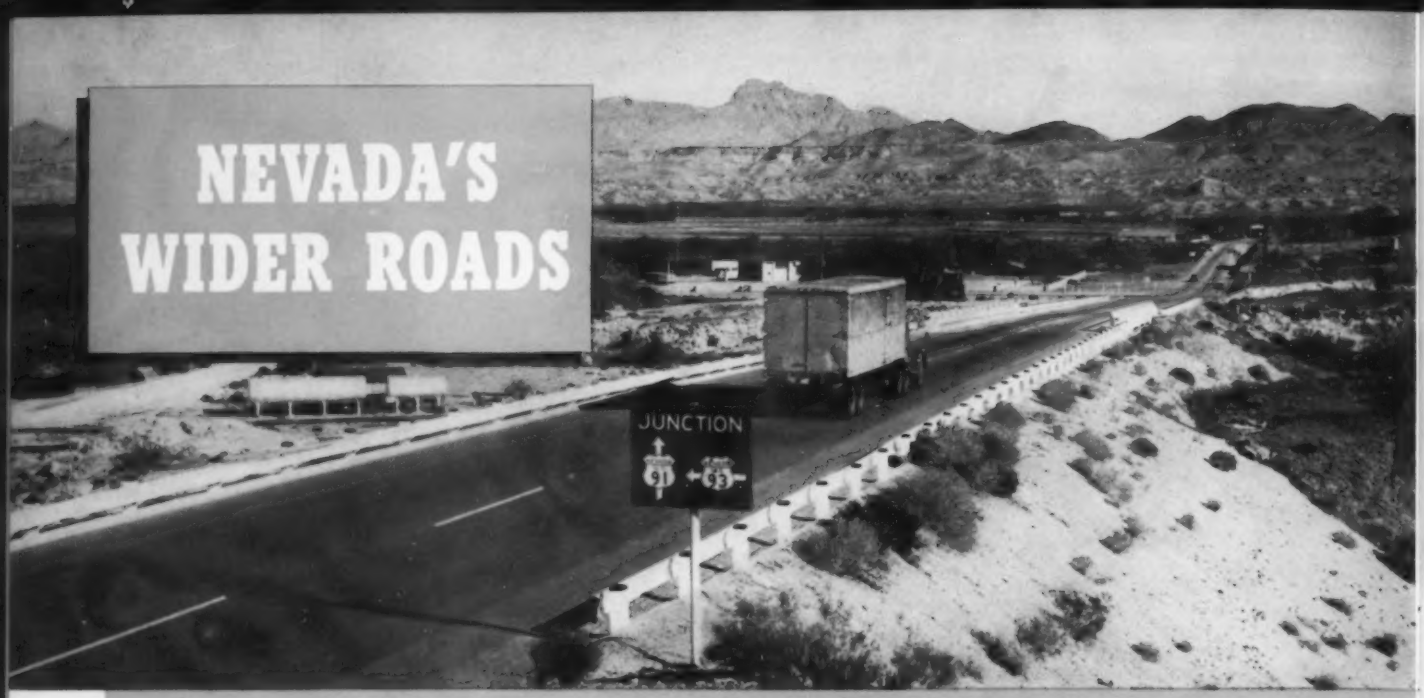
2. Rolling the subbase "ballast" with 3-wheel roller

3. Smoothing the asphalt leveling course with pneumatic-tired roller

4. Paving the asphalt wearing surface in two courses

Photos: Banning

NEVADA'S WIDER ROADS



On U. S. 91, along the Las Vegas route — a forty foot asphalt pavement with a line of demarcation separating the 12 foot middle lanes from the outer 8 feet on each side. *Photo: Nevada Highway Department*

In respect to population, Nevada is the smallest State in the Union, but in size it is sixth largest. Yet despite its sparse population and wide areas of uninhabited countryside, Nevada has a state highway system some 6,226 miles in length, much of which is unpaved. All pavements—3,375 miles of them — with the exception of 4 miles of portland cement concrete in Las Vegas, are asphalt.

The Nevada Highway Department is small but efficient and works closely with the local District Office of the U. S. Bureau of Public Roads. In common with the rest of the country, some highway deficiencies have developed, and a program has been started to eliminate them through widening, realignment or new construction. Although this program covers many areas throughout the State, the work being done on U. S. 40, one of the principal routes on the National System of Interstate Highways, will receive special consideration here.

A transcontinental route, U. S. 40 carries the bulk of through traffic, including both trucks and passenger cars, 411 miles across Nevada. Except for a few stretches where the road runs through the mountains, improvements in grade and alignment have made possible design speeds up to 70 miles per hour, among the highest in the country. Truckers especially like to use this highway because of its easy grades and smooth-riding surface.

STAGE DEVELOPMENT OF U. S. 40

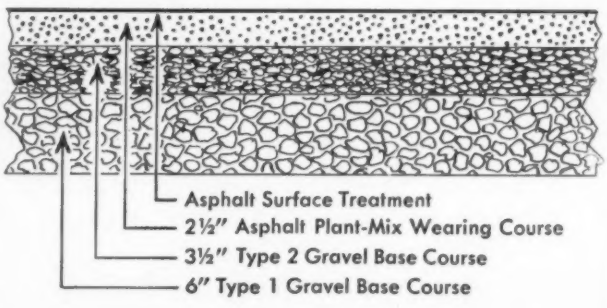
History shows that U. S. 40 was once a gravel road with a few strips of portland cement concrete or asphalt pavement only 9 to 16 feet wide. All the portland cement sections have since disappeared, either through realignments or blanketing with asphalt — the entire 411-mile length is now paved with asphalt.

Later the standard paved width of U. S. 40 became 18 feet, with subsequent sections constructed up to 24 feet. Shoulders were, in general, of gravel or native desert materials, but since 1935 these have all been stabilized with asphalt and constructed to 8-foot widths in non-mountainous terrain. New construction now in progress consists of realignment and grade changes and the construction of a four-lane divided highway in the Reno area.

Traffic and economic surveys indicate only a few locations in Nevada where the construction of four-lane divided highways is justified, namely in the Reno and Las Vegas areas. On U. S. 40 east of Reno, a four-lane divided highway three miles in length was constructed in 1952. Plans and specifications are now being prepared to extend this highway another six miles to the east, with further extension to Wadsworth, thirty miles east of Reno, contemplated for the future. Similar construction from the California state line to Reno is planned and some of it is now underway.

The typical pavement cross-section is 2½" of asphalt plant-mix over 3½" Type 2 gravel base, over 6" of Type 1 gravel base. The pavement covers the full width of four twelve-foot traffic lanes and the eight-foot shoulders, with surface treatment applied to the former. This treatment consists of an application of .30 gallon per square yard of high viscosity asphalt emulsion and approximately 18 pounds to 22 pounds per square yard of ⅜-inch stone chips. The eight-

TYPICAL PAVEMENT SECTION — U. S. 40 EAST OF RENO



foot shoulders have a flush seal of .10 to .15 gallon per sq. yard of high viscosity asphalt emulsion without cover. This provides a definite line of demarcation between the traffic lanes and the shoulders. On the project starting at the California state line an asphalt cement penetration grade 150-200 will be used. In the Las Vegas area recent contracts have specified penetration grades of 85-100 or 120-150.

WIDER ROADS SPEED TRAFFIC

Of particular interest in the Nevada highway improvement program is the widening of many miles of existing two-lane sections of Route U. S. 40 and other highways in the state. It has been pointed out that traffic conditions warrant the construction of only a few miles of four-lane divided highways in the system, but due to the many long tangents where traffic speeds increase, two-lane roads of greater width have become desirable. Hence the highway department has inaugurated a program to widen two-lane sections to 40 feet on U. S. 40 and to 26-40 feet on other primary state highways.

This construction involves both safety and economic factors. The greater widths not only provide high speed traffic with more room for passing, but also prevent damage caused by heavy transport trucks driving too near the edge of the pavement. This is a frequent occurrence which has resulted in costly maintenance on two-lane roads having unpaved or untreated shoulders. Snow removal is also facilitated on the wider pavements, particularly in areas of heavy fall or drifting.

In selecting a 40-foot pavement width for two-lane roads, it is not the intention of the State to establish 20-foot driving lanes. Traffic is channeled into 12-foot driving lanes by the treatments applied to the finished pavement surface. The 24-foot center section of the pavement is treated with .30 gallon per square yard of high viscosity asphalt emulsion and 18 to 22 pounds per square yard of $\frac{3}{8}$-inch stone chips. The remaining eight feet on either side have a flush coat of .10 to .15 gallon per square yard of high viscosity asphalt emulsion without cover. This provides the same line of demarcation as obtained by similar treatment on the four-lane divided highways and tends to prevent traffic from meandering. However, the eight-foot flush-sealed sections, which now serve as shoulders, are sufficiently strong to carry trucks or other vehicles in emergencies.

There is no typical cross section for this type of construction since widening operations may vary. In some instances equal widths are added to each side of the existing road; in others, the center line is moved to one edge of the existing pavement, with the result that the widening operation is practically all new construction. During construction it has been found necessary to make a number of changes, by work orders, in the original design cross sections.

Tests are made on the soils under the existing pavement and in the areas of the proposed widening. These widening areas are treated as new construction, with appropriate thicknesses of base materials specified. Where existing pavement and base are inadequate in thickness, provision is made either to superimpose additional base material or to scarify the pavement, blade it back and place additional base. The old pavement then may be processed and relaid or moved to another location for use as base material. Grade and profile largely control the procedure to be followed.

When the 40-foot width of old pavement and new widened areas have been brought to grade, a uniform blanket of hot plant-mix asphalt pavement $2\frac{1}{2}$ inches in thickness is placed over the entire width. The specifications for the plant mix are the same as those for the four-lane divided highway sections. It is expected that asphalt cement of penetration grade 120-150 will be used, except in some cases

In Las Vegas – U. S. 91 widens to a four lane divided highway. *Photo: Nevada Highway Dept.*

where penetration grade 150-200 will be specified. To date over 200 miles of pavement on U. S. 40 have been widened to 40 feet. Road mix shoulders were constructed on some of the earlier projects but the policy now is to use asphalt plant-mix over the entire section.

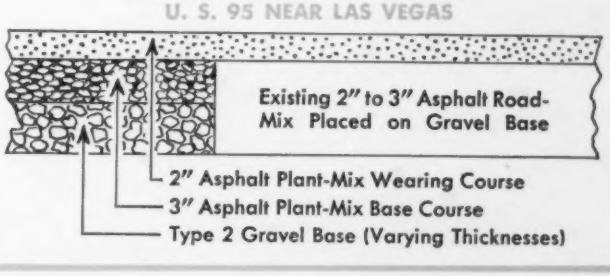
WIDENING AND RESURFACING U. S. 95

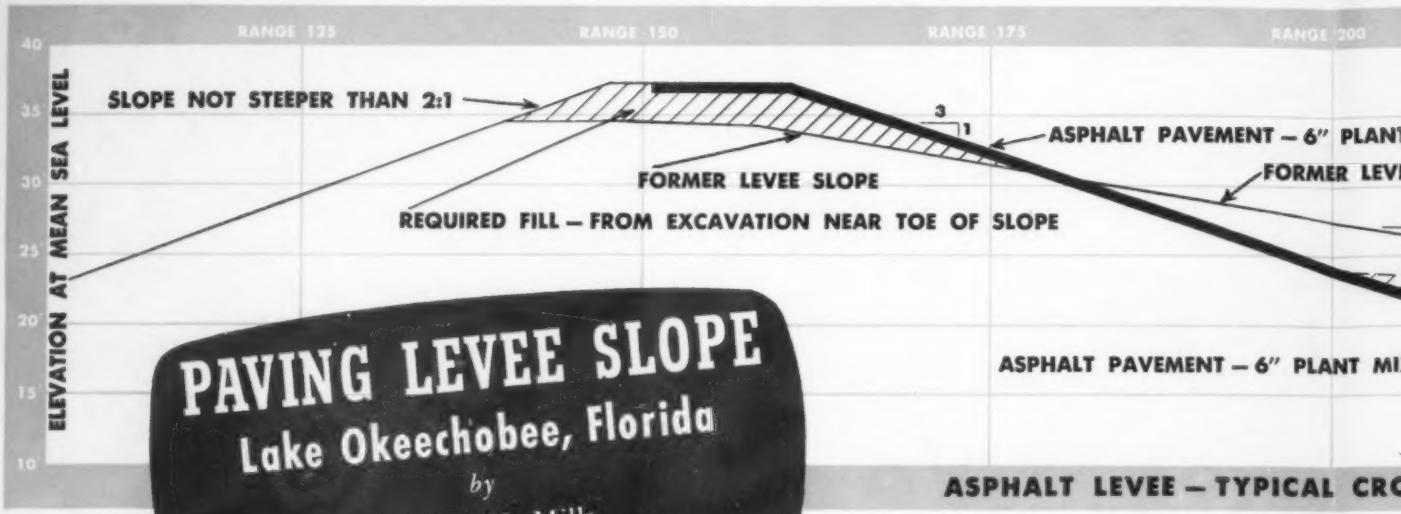
Another project more typical of future widening procedure is the section of Route U. S. 95 from Las Vegas to Camp Desert Rock, the Atomic Energy Commission's Nevada Test Site. Approximately 58 miles in length, this was the longest single plant-mix asphalt paving project in the United States ever let in one contract.

The old existing asphalt pavement, a slow-curing cutback asphalt (SC-2) road mix 2 to 3 inches thick, with a medium-curing (MC-2) flush seal, is 18 to 20 feet wide and still in excellent condition after 18 years of service. When the A. E. C. and Second Army moved in, causing an increase in traffic, the pavement proved too narrow to accommodate it safely and economically. In 1952, the contract was let to widen the old pavement to 26 feet.

This is an example of widening by adding equal increments to both sides of the existing pavement, accomplished by trenching and placing various thicknesses of Type 2 gravel base compacted to within 3 inches of the grade of the existing pavement. The final 3 inches consists of a lean asphalt plant-mix. A 2-inch blanket of asphalt plant-mix is then placed over the entire 26 feet. Specifications for the mix were the same as those already described, with slight changes in grading. The percentage of asphalt in the base varied from 3.1 to 3.5 per cent and in the surface mix from 4.5 to 5.7 per cent. Asphalt cement penetration grade 120-150 was used in both cases. The entire project required approximately 160,000 tons of asphalt plant-mix.

TYPICAL IMPROVEMENT SECTION
U. S. 95 NEAR LAS VEGAS


Existing 2" to 3" Asphalt Road-Mix Placed on Gravel Base
2" Asphalt Plant-Mix Wearing Course
3" Asphalt Plant-Mix Base Course
Type 2 Gravel Base (Varying Thicknesses)



PAVING LEVEE SLOPE

Lake Okeechobee, Florida

by

William H. Mills

District Engineer, The Asphalt Institute

For many years after asphalt was first produced on a large scale in this country, its use was confined largely to the paving of roads, to roofing and to waterproofing. As new techniques were developed in the paving and construction fields, however, and engineers grew to recognize more and more the extreme versatility of the product, many new uses were found for which asphalt was particularly suited. In the past twenty years, for example, engineers have made considerable headway toward the solution of flood control problems and they have been aided to a great extent by the use of asphalt in their work. As a protective pavement on earth levees and revetments constructed on the banks of rivers and lakes in areas where frequent severe storms provide a constant threat of devastating floods, asphalt has proved to be of inestimable value.

One of the areas of this country most vulnerable to tropical storms is southern Florida. In years past, violent hurricanes have brought disaster to the low, fertile farm areas of the Everglades to the south and east of Lake Okeechobee. This large expanse of water, the southern end of which is located approximately 40 miles west of West Palm Beach, has frequently overflowed its banks and, in 1928, some two thousand lives were lost due to the flooding of vast areas by water blown from the swollen lake.

To help prevent further catastrophes of this kind the U. S. Corps of Engineers, between 1932 and 1937, constructed a great system of levees along 84 miles of the lake shore. Through the years, however, subsequent storms caused serious erosion of the levee slopes, prompting the engineers to study methods for protecting them against damaging wave action.

ASPHALT PAVEMENT SELECTED

In 1939, on the east side of the lake, a series of test sections were constructed on the existing 6 to 1 levee slopes upon which several kinds of pavement were placed to determine which would provide the best protection. One section was paved with portland cement, another with medium-curing cutback asphalt, and two with plant-mix asphalt. On one of the two latter sections the asphalt was reinforced with wire mesh; on the other, with cotton fabric. When the Jacksonville District Office of the Corps of Engineers made an inspection and additional studies of the sections in 1950, it was indicated that a protective pavement built of plant-mix asphalt would best meet all requirements.

Plans were made to pave with a semi-hot asphalt mix 4.8 miles of the levee near the town of Clewiston (southwest shore) and 1.6 miles on the east shore near Pahokee. This type of mix was selected for its construction economy and long-lasting flexibility. As finally developed, the project provided for increasing the existing 6 to 1 levee slope to 3 to 1, and constructing a 6-inch Plant-Mix Sand Asphalt pavement on the lake side and top of the levee.

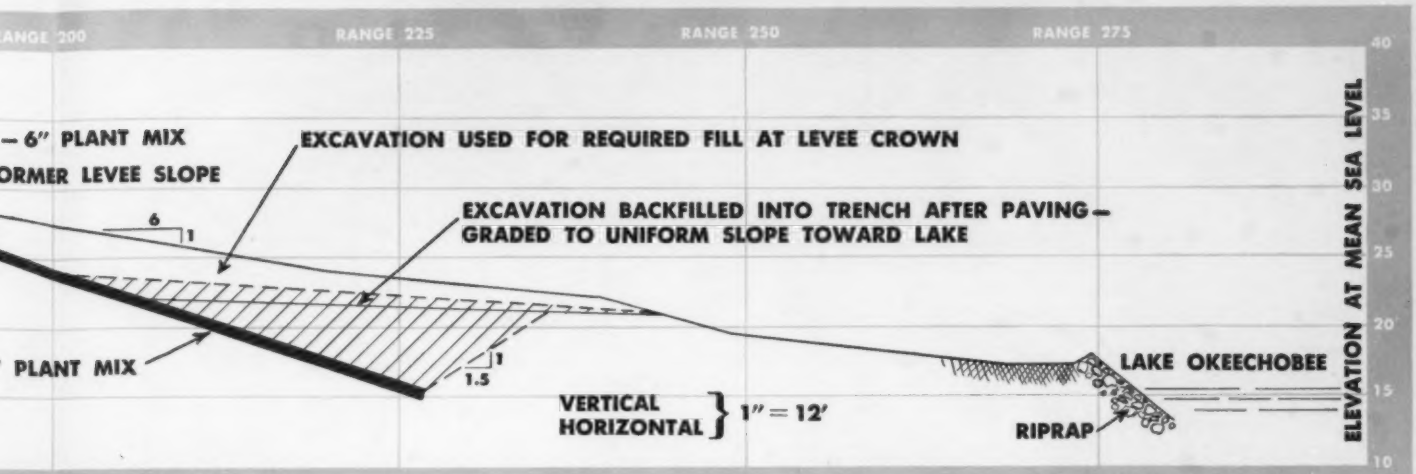
1. EXCAVATING TRENCH AT FOOT OF LEVEE SLOPE. *Photo: Mills*

2. WINCH LOWERING ASPHALT-FILLED TRUCK DOWN SLOPE. *Photo: Mills*

3. DUMPING ASPHALT MIX INTO FINISHER. *Photo: Mills*

4. SPREADING ASPHALT FROM OPEN-END SPREADER BOX. *Photo: U. S. Corps of Engineers*

5. R 6- P



ICAL CROSS-SECTION

Courtesy U.S. Corps of Engineers

CONSTRUCTION PROCEDURE

The initial operations involved re-sloping the levee, raising its height by four feet and constructing a trench at the toe of the paved area below the water line (see cross-section above). Bulldozers pushed soil up the slope from the lower part of the levee and the trench was excavated with a drag line. Part of this trench material was hauled to the asphalt plant site for use as an aggregate in the mix. The fill material was spread in layers not more than 9 inches thick and compacted by three passes of a crawler-type tractor. After rough grading, the slope was trimmed to section and then recompacted with proper water content by two passes of the crawler-type tractor.

The paving mix consisted principally of a mixture of sand, shell, and soft limestone or marl particles varying in size from 1½ inches to dust. The binder was liquid asphalt (Rapid Curing Cutback) containing not more than 10% of solvent. Laboratory tests showed that 11% of RC-5 Cutback Asphalt would be required to produce the rich mix considered necessary for the work. With the equipment available, however, it was found preferable to reduce this content to 9%-10% of cutback with a seal coat added to the finished surface. Mixing temperatures were specified at 175° to 220°F.

On the top of the levee the contractor built a mixing plant consisting of a two-drum drier connected to a small storage bin serving a continuous mixer elevated above a loading ramp. In this way the material from the mixer could be discharged directly into a truck. Only partial drying of the aggregate was required.

Operating longitudinally along the levee slope a Barber-Greene Finisher placed the initial paving. The hopper of this equipment was loaded with asphalt mix from a truck lowered down the slope by a winch. The finisher paved about a mile of the levee while, in areas where a very sandy subgrade was encountered, it was necessary to spread the mix by use of an open-end spreader box pulled up the slope by the winch.

After the surface of the mix had cured for 24 to 48 hours it was rolled and compacted by two passes of a 6-ton smooth-wheel roller. Two to four days later the pavement was again rolled, this time by a 9-wheel, 6-ton rubber-tired roller, with a seal coat of RC-2 liquid (cutback) asphalt then applied to the surface. To pave the 4.8-mile levee section 1,475,000 gallons of asphalt were used; the later 1.6 section required 491,000 gallons — a total of nearly 2,000,000 gallons of asphalt for the entire project.

An inspection of the entire levee slope made in March, 1953, nearly two years after its completion, showed the pavement still in excellent condition.

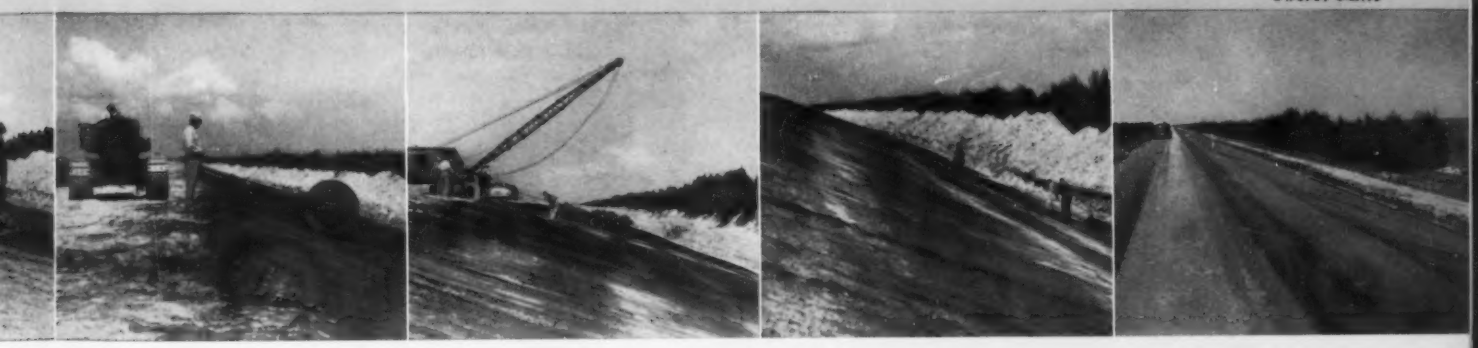
There are many extensive areas where asphalt paving of levees is an urgent need, not only in the southeastern part of the United States but also throughout the nation and, in fact, most of the world. The Corps of Engineers has under development a series of levees and canals for the area between Lake Okeechobee and Miami. Some of these levees are composed of sandy, easily eroded soils which will require the maximum protection of a durable, long-lasting asphalt pavement.

5. ROLLING PAVEMENT WITH 6-TON SMOOTH-WHEEL ROLLER. *Photo: U. S. Corps of Engineers*

6. ROLLING WITH 6-TON PNEUMATIC-TIRED ROLLER. *Photo: U. S. Corps of Engineers*

7. APPLICATION OF ASPHALT SEAL COAT WITH HAND HOSE. *Photo: U. S. Corps of Engineers*

8. THE COMPLETED PROJECT SHOWING THE ASPHALT PAVEMENT IN PLACE. *Photo: Mills*



ASPHALT CEMENTS

By John M. Griffith
Engineer of Research

Second in the Series "Asphalt as a Material"

The first article in this series (Asphalt Institute Quarterly, April 1953) described asphalt as a versatile family of materials varying widely in properties and adaptable to many engineering uses. A most important member of this family is the group of asphalts known as *asphalt cements* which, for the purpose of this article, will be assumed to include products made by the several refining processes.

The dividing line between asphalt cements and the liquid grades is an arbitrary one, since asphalts range in consistency from the most fluid to the very hard, low-penetration grades of asphalt cement. For practical purposes, however, this dividing line has been set at approximately the maximum value at which the penetration test is of significance, a penetration value of 300 being the selected upper limit. The consistency of softer asphalts, those of the liquid grades, is measured by a viscosity test.

USES OF ASPHALT CEMENTS

Asphalt cements are most commonly used in hot-mix asphaltic pavements for roads, airfields, sidewalks, parking areas, dam facings, swimming pools, industrial floors and many other structures which require paving. They are also included in such every-day items as battery cases, tires, roofings, paints, wall boards, electrical insulating tape and literally thousands of others. Asphalt cements are used as membrane linings for irrigation canals and reservoirs, as a protective coating on pipe lines, for waterproofing and damp-proofing structures and for undersealing rigid pavement slabs. Because of their versatility asphalt cements may be "tailor made" to meet the many requirements of these various applications. To cover all the details required for such applications is beyond the scope of this article, but there are certain basic physical characteristics of asphalt cements which are included in most specifications, in addition to the special requirements for specific applications. A brief discussion of these basic properties and the methods by which they are measured may be helpful in achieving a better understanding of this all-purpose cement.

PENETRATION

As described in the first article of this series, the consistency of an asphalt cement is measured by the *penetration test*. A weighted needle is allowed to bear on the surface of a dish of asphalt of standard test temperature for a given length of time. The depth of penetration of the needle into the asphalt is termed the penetration of the asphalt and is measured in units of 1/10 millimeter. The needle penetrates more into soft asphalts than into the harder grades, and thus the lower the penetration, the harder the asphalt. This test is the basis upon which most asphalt cements are classified into standard penetration ranges, and the standard conditions for it are fully prescribed in the Method of Test D5 of the American Society for Testing Materials (ASTM).

SOFTENING POINT

The consistency of an asphalt cement may also be measured by determining its *softening point,* a procedure diagrammatically illustrated in Figure 1. A sample of asphalt loaded with a steel ball is confined in a brass ring suspended in a beaker of water. As the water is heated at a given rate, the asphalt softens and eventually drops, along with the ball, through the ring. At the moment the asphalt and the steel ball touch the bottom of the beaker, the temperature of the water is recorded; this temperature is designated as the softening point of the asphalt. All conditions for this test have been standardized and are fully prescribed in ASTM Method of Test D36.

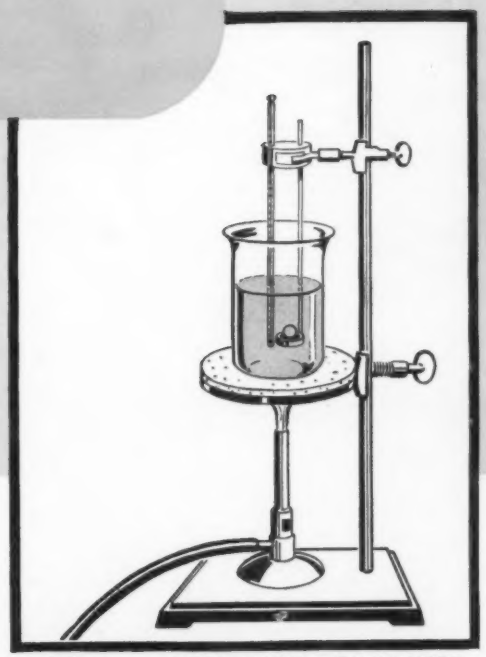


FIGURE 1 — SOFTENING POINT TEST

In many applications the softening point, as a measure of consistency, is of as much interest to the user as the penetration test, particularly in those cases where the asphalt cement is to be used in thick films such as crack fillers or for undersealing concrete slabs. Where the asphalt cement is to be used in thin films such as in paving mixes, however, this test is of negligible importance.

The softening point test may be used in conjunction with the penetration test to furnish a general indication of the relative temperature susceptibility of two or more asphalts of the same penetration. For example, of two asphalts having the save penetration value, the one with the higher softening point is less temperature susceptible — that is, it softens less rapidly as its temperature is raised.

DUCTILITY

In many applications, *ductility* is an important characteristic of asphalt cements. The presence or absence of ductility, however, is usually of more significance than the actual degree of ductility. Asphalt cements possessing ductility are normally more cementitious than asphalt cements lacking this characteristic. On the other hand, asphalt cements having an exceedingly high degree of ductility are usually more temperature susceptible. In some applications, such as paving mixes, ductility and cementitiousness are more important; while in others, such as slab undersealing and crack filling, the more essential test measure is low temperature susceptibility.

Ductility of an asphalt cement is measured by an "extension" type of test as illustrated in Figure 2. A briquette of asphalt cement is cast under standard conditions and to specified dimensions. It is then brought to a standard test

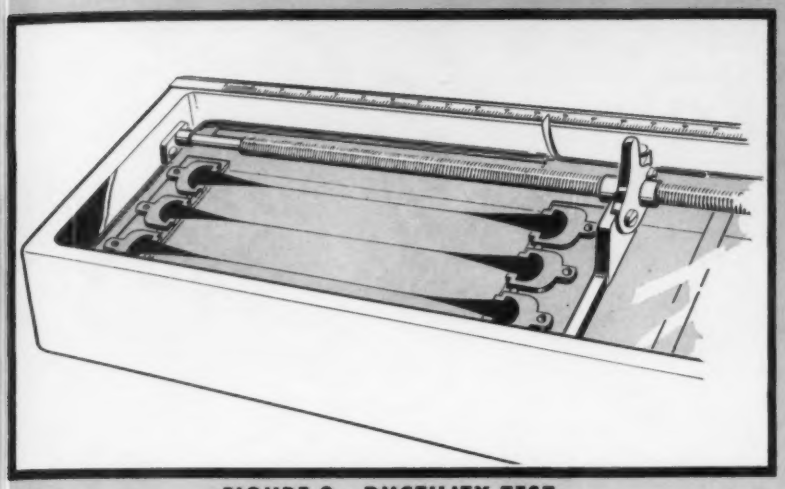


FIGURE 2 — DUCTILITY TEST

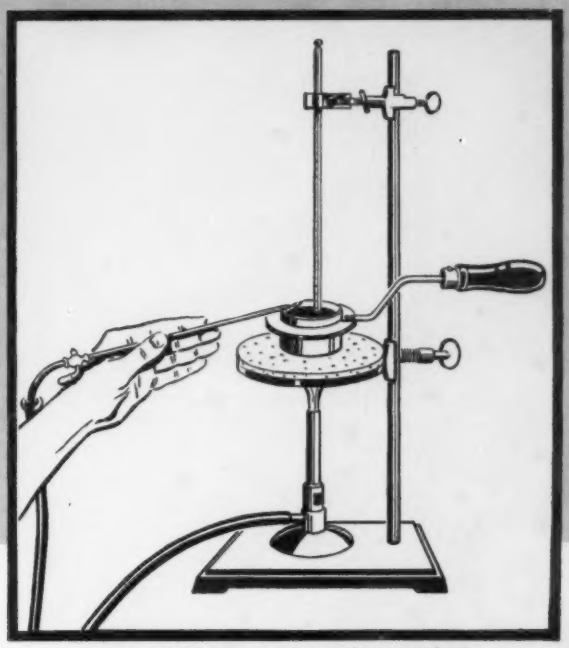


FIGURE 3 — FLASH POINT TEST

temperature and pulled or extended at a specified rate of speed until the thread connecting the two ends breaks. The length of pull (in centimeters) at which the thread of material breaks is designated as its ductility. Standard conditions for this test are fully prescribed in ASTM Method of Test D113.

FLASH POINT

The *flash point* of an asphalt cement is of interest primarily to the user, since the material must be heated for application or mixing. It tells the user how much the material may be safely heated without danger of instantaneous flash in the presence of an open flame. This temperature, however, is usually well below that at which the material will burn. This latter temperature is called the "fire point" but is seldom included in specifications on asphalt cements.

The flash point of an asphalt cement is measured by the Cleveland Open Cup Flash Point Test under standard conditions fully prescribed in ASTM Method of Test D92. A schematic illustration of the test is shown in Figure 3. A brass cup is partially filled with asphalt cement and heated at a prescribed rate. A small flame is played over the surface of the sample periodically, and the temperature at which sufficient vapors are released to produce an instantaneous flash is designated as the flash point of the particular asphalt cement.

LOSS ON HEATING

In most applications, the user specifies the properties of an asphalt cement which he wishes to have in the finished product. Since the material must be heated for application or mixing, its properties should not change appreciably when heated to specified application or mixing temperatures. Such temperatures may vary but they usually are not greatly in excess of 325°F. The *Loss on Heating Test* was therefore devised to prevent the inclusion of excessive amounts of volatile materials, the loss of which might cause appreciable changes in some of the properties of the asphalt cement.

Results of this test should be considered only as a general indication of what may be expected under service conditions. Asphalt film thicknesses vary widely from extremely thin, in the case of paving mixes, to relatively thick, in the case of joint sealers and similar applications. The test is therefore more appropriate in the latter case than in the former.

In the test, a 50-gram sample of material is placed in a metal cup which in turn is placed in a well-ventilated oven, maintained at 325°F. for a period of five hours. The weight loss of the sample during this period, expressed as a per cent of the original weight, is termed "loss on heating." Procedures for this test are fully prescribed in ASTM Method of Test D6.

SOLUBILITY

Pure asphalt cement is completely soluble in Carbon Disulphide and, except for carbenes, completely soluble in Carbon Tetrachloride. As mineral matter and other foreign products are insoluble in these solvents they may therefore be used to detect the presence of such matter.

For reasons of safety and convenience, Carbon Tetrachloride is the preferred solvent more generally used. In instances, however, where asphalt cements do not meet the specification requirements for *solubility* when using Carbon Tetrachloride, the test should also be run with Carbon Disulphide as the solvent. Where differences in solubility are encountered by use of the two solvents, the presence of carbenes is indicated. Where this difference is greater than about 0.5 per cent, it is generally conceded to mean that the asphalt cement has been overheated or "cracked" in the process of manufacture. On the other hand, cracked products do not always show the presence of carbenes.

The determination of solubility is simply a process of dissolving the asphalt cement in the solvent and separating out the insoluble matter. The procedure is fully prescribed in ASTM Method of Test D4.

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To summarize, asphalt cements are the semi-solid to solid segment of the asphalt family and are used for an extremely wide variety of engineering and industrial applications. They are "tailor made" for many of these applications, characteristics being modified to fit the specific need. Generally speaking, however, asphalt cements have certain basic characteristics, prescribed in most specifications as needed. The intelligent use of specifications to prescribe an asphalt cement for a specific purpose is the job of the engineer and he should write this prescription with full knowledge of the significance of the various test methods.

THE *ALL-ASPHALT* NEW HAMPSHIRE TURNPIKE

By Edward M. Howard, *District Engineer, The Asphalt Institute*

Opened to traffic June 25, 1950, this New Hampshire Toll Road is proving itself a wise investment. Built of Asphalt at a saving of $1,250,000, with the alternate bid for rigid pavement 25% higher, it cost the taxpayers $85,000 less per mile for a better, longer-lasting road.

Photo: Howard

To relieve the congested traffic conditions then existing on U. S. Route 1, the New Hampshire State Legislature in 1947 authorized the issuance of bonds in the amount of $7,500,000 for the construction of a toll road from the Massachusetts state line to connections with the interstate bridge at Portsmouth, New Hampshire, and across to the Maine Turnpike.

On September 27, 1948, after all preliminary requirements had been fulfilled, four competitive bids were received by the State Highway Department. Of these, Alternate C $5,233,675.50 for Asphalt Design and Alternate D $6,474,809.50 for Portland Cement Concrete were considered comparable and the award made for Asphalt at a saving of $1,241,134.00.

THE TURNPIKE DESIGN

Using the same master plan for grade separations and structures throughout the turnpike the engineers took advantage of the economies inherent in repetitive forming without sacrificing any modern high speed design requirements. Grades were restricted to a maximum of two percent and curves to one degree. The pavement extends over two 24-foot double lanes, separated throughout by a 24-foot depressed median strip. Longitudinal drainage is provided through this strip (see cross-section below). Shoulders eleven feet in width are of bank-run gravel; the right-of-way width three hundred feet; the turnpike length fifteen miles.

The pavement consists of a double asphalt surface treatment, a first application of 0.6 gallon of rapid-curing asphalt cutback (RC-3) per square yard with ½" crushed stone chips; and a second application of 0.2 gallon of RC-3 with ⅜" crushed stone chips; these treatments being placed upon a 3" layer of 2" crushed stone penetrated with 2 gallons per square yard of asphalt (85-100 penetration).

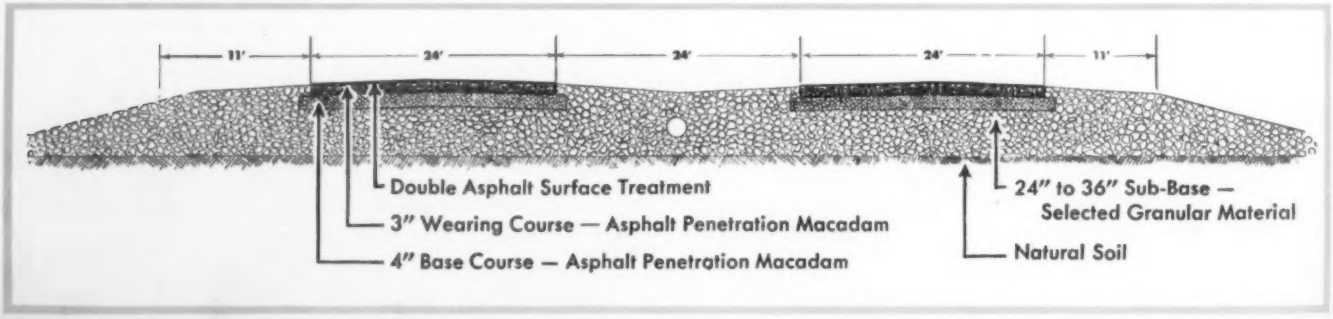
Under this 3" course a 4" layer consists of 2" crushed stone penetrated with 1½ gallons per square yard of 85-100 penetration asphalt and filled with ½" crushed stone chips. This rests upon a foundation of 24" to 36" bank-run gravel above natural soil.

Excavation in the roadway amounted to 100,000 cubic yards of muck or peat, and 1,111,600 cubic yards of unclassified material (including 180,000 cubic yards of rock). Some of the rock cuts ran to a depth of 35 feet. In addition there were 1,000,000 cubic yards of earth borrow and 600,000 cubic yards of gravel sub-base borrow. Favored by unusually mild weather during the winter months, the contractor was 85% completed on the job when but 55% of the construction time had elapsed. Borrow pits, nearly all of which were adjacent to the right of way, facilitated rapid and maximum use of available local materials.

TRAFFIC GROWTH

Now in operation for three years, the turnpike is steadily becoming more and more popular for every type of motor traveler, showing substantial gains in traffic and revenue each year. The reason for its ever-increasing popularity can unquestionably be attributed to the rapid, uncongested, and safe movement of traffic, coupled with the comfortable and smooth riding qualities provided by the asphalt pavement.

TYPICAL PAVEMENT CROSS-SECTION — NEW HAMPSHIRE TOLL ROAD



AN "OLD" ROAD IN LOUISIANA

The Vivian-Rodessa Road
After 34 Years of Stage Development

By William H. Rhodes
District Engineer, The Asphalt Institute

Through the oil fields of northwest Louisiana on State Highway Number 8 runs the 6.5-mile, 34-year-old Vivian-Rodessa Road. Originally graded in 1919 and later paved and resurfaced with asphalt in successive stages, it stands as a tribute to the careful planning and fine work of the highway department of Caddo Parish.

Traffic between the towns of Vivian and Rodessa has always been heavy. The discovery of oil many years ago resulted in the mushroom growth of towns and settlements in the area and, as the oil fields were developed, increasingly heavy equipment and materials moved over the road. To meet these traffic demands the parish highway department in 1921 widened the road to 14 feet and added 6 inches of pit-run gravel to the graded dirt section, applying a double asphalt surface treatment later in the year. Two years later (1923) the surface was scarified, with 4 inches of pit-run gravel added and thoroughly compacted into the old surface course. On this was spread a double asphalt surface treatment.

HEAVIER TRAFFIC DEMANDS STRONGER, WIDER ROAD

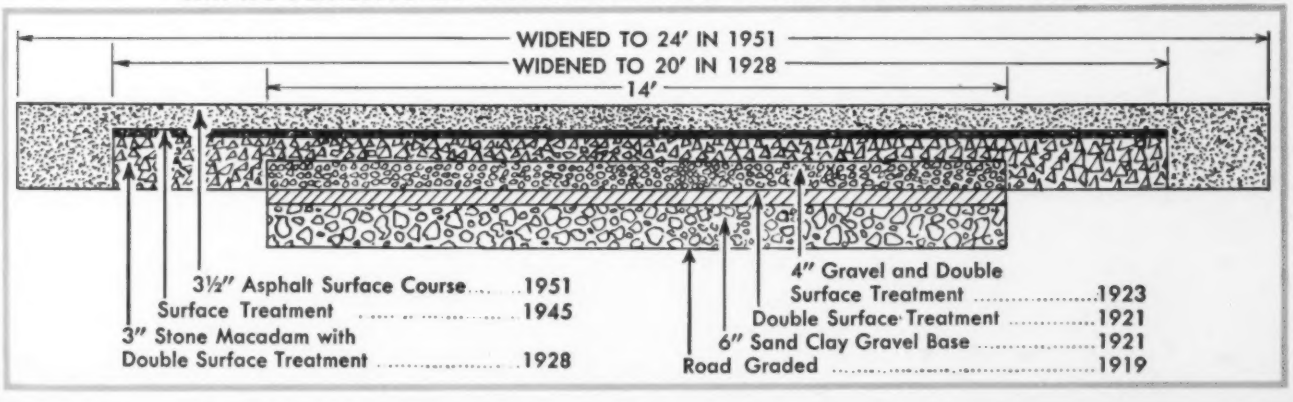
This stage of construction carried ever-increasing traffic, both in weight and number of vehicles, until 1928, when the roadbed was widened to 20 feet and a 3-inch layer of limestone macadam added. The widening was carried down to the depth of the previous layer and the macadam course given a double surface treatment. For the next 17 years the road served with no further improvement other than routine maintenance. In 1945 a single surface treatment seal was applied.

In late 1951 the State let a contract for their regular widening and resurfacing design construction using hot-mix asphalt with crushed gravel aggregate. Then 32 years old, the Vivian-Rodessa Road was widened to 24 feet, with the widening strips of asphaltic concrete carried down to a depth of 8 inches. The surface of the old road was somewhat irregular and, to secure the smoothest possible wearing course, a motor patrol grader with a long wheel-base was used to spread the binder.

ALL EARLIER CONSTRUCTION USED

This road is but one of many examples demonstrating the value of stage construction using local materials and asphalt. All earlier construction has been utilized to the full, with improvements added as traffic weights increased. These step-by-step developments are shown chronologically in the cross-section below. At the present time—and for the future—the State, the parish and the community have the most modern type of pavement, geared for heavy-duty service and incorporating all previous construction and costs. Nothing has been abandoned or thrown away. The investment is all at work for the taxpayer.

IMPROVEMENTS BY ASPHALT STAGE DEVELOPMENT 1919-1951


WIDENED TO 24′ IN 1951
WIDENED TO 20′ IN 1928
14′
3½″ Asphalt Surface Course 1951
Surface Treatment 1945
3″ Stone Macadam with
Double Surface Treatment 1928
4″ Gravel and Double
Surface Treatment 1923
Double Surface Treatment 1921
6″ Sand Clay Gravel Base 1921
Road Graded 1919

BURRILL ENNIS. *On July 19th, by the death of Burrill Ennis, a member of the Board of Directors representing the Sinclair Refining Company, the Asphalt Institute lost the guidance and counsel of an able executive of wide experience in the asphalt industry.*

ASPHALT INSTITUTE APPOINTMENTS

ARVIN S. WELLBORN

Chief Engineer, The Asphalt Institute

Formerly Managing Engineer of the Pacific Coast Division of the Asphalt Institute, Arvin S. Wellborn has been promoted to Chief Engineer, with headquarters in New York City.

A graduate of the University of Arkansas Engineering School, Mr. Wellborn was first employed by the Arkansas Highway Department in the Department of Materials and Tests from 1933 to 1940. There his last position was Soils Engineer. After two years as Chief Engineer and Assistant Manager of an asphalt pavement construction firm, he entered the U. S. Navy in 1942, serving in the South Pacific, Alaska and Washington State, with the rank of Lieutenant Commander. Following a year in general contracting, in 1947 he was employed by the Navy as Engineer in Charge of Design and Construction of Airfields in Cuba, resigning in 1949 to join the Asphalt Institute.

Mr. Wellborn is a Registered Professional Engineer and a member of the American Society of Civil Engineers, the American Chemical Society, and the American Road Builders Association.

BERNARD A. VALLERGA

Managing Engineer, Pacific Coast Division

Bernard A. Vallerga, most recently of the College of Engineering at the University of California, replaces Arvin S. Wellborn as Managing Engineer of the Asphalt Institute's Pacific Coast Division at San Francisco.

Graduating from the University of California, Mr. Vallerga served for a number of years with a private engineering firm and as consultant and adviser to many large engineering and contracting organizations. After a five-year tour of active duty with the Army Ordnance Department during World War II, Mr. Vallerga in 1947 joined the Civil Engineering faculty of the College of Engineering at the University of California (Berkeley) where, as an Assistant Professor, he organized and presented courses of instruction in the field of asphalts and asphaltic pavement design and construction and in soil mechanics and foundations.

Mr. Vallerga is a registered Civil Engineer in California and holds memberships in the American Society of Civil Engineers, American Society for Testing Materials, Association of Asphalt Paving Technologists, Highway Research Board and the American Society for Engineering Education.

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